The Time of the Paramagnetic Spin-Spin Relaxation in the Absence of a Static Magnetic Field for $Co(NH_4)_2 (SO_4)_2 .6 H_2O$ at Helium Temperatures

SOV/56-35-2-28/60

used also for the calculation of the time τ_{ss} of the paramagnetic spin-spin relaxation according to the formula of Brur (Ref 3). The concrete calculations were carried out for $Co(NH_4)_2 (SO_4)_2 .6 H_2O$ for helium temperatures; the results of these calculations are given in a table. The author thanks Professor S. A. Al'tshuler, for this theme and for his interest in this paper. There are 1 table and 6 references, 1 of which is Soviet.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet (Kazan' State University)

SUBMITTED: April 4, 1958

Card 3/4

69149
S/139/59/000/06/005/034
E032/E114

24.7900

AUTHOR: Kopvillem, U.Kh.

TITLE: Spin-Spin Paramagnetic Relaxation Time at Low Temperatures in Monocrystals with Magnetically Nonequivalent Ions

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Fizika, 1959, Nr 6, pp 21-30 (USSR)

ABSTRACT: In the present work, use is made of the methods developed by the present author in Ref 2 in order to study the spin-spin relaxation in a spin system isolated from the lattice and formed by the magnetic moments of N/2 ions of type (I,k) and N/2 ions of type (α,β). The following approximations are made: 1) the field E at the point of location of the paramagnetic ions has an axial symmetry axis ϵ ; 2) the axes ϵ^k and ϵ^β corresponding to magnetically nonequivalent ions k and β form an angle of $\pi-2\alpha$ with each other; 3) in the corresponding principal coordinate systems (ξ^k, η, ϵ^k) and ($\xi^\beta, \eta, \epsilon^\beta$) the g-tensors of the k and β ions have the same form; 4) the effective spin of all the paramagnetic ions is 1/2; 5) the spin-spin relaxation time is much smaller than the spin lattice relaxation time; 6) in the spin system there

Card 1/3

Spin-Spin Paramagnetic Relaxation Time at Low Temperatures in Monocrystals with Magnetically Nonequivalent Ions

are no energy gaps which separate different parts of the spin system and which cannot be bridged by the internal interaction mechanism; 7) the paramagnetic absorption curve in the absence of the static field H_0 has a gaussian form; 8) the radio frequency field H_t is small and the spin-spin relaxation time T_{cc} is independent of the intensity of excitation of the spin system by this field. The Hamiltonian which satisfies the above conditions is given by Eq (2). This Hamiltonian is used to derive formulae for the reduced second moment (p 23). The analysis is used to estimate the spin-spin paramagnetic relaxation times in the absence of a static magnetic field in the case of monocrystals of $Co(NH_4)_2(SO_4)_2 \cdot 6\ H_2O$ at helium temperatures.

Acknowledgement is made to S.A. Al'tshuler who suggested this subject.

Card 2/3

There are 2 figures and 11 references, of which 5 are Soviet, 1 Japanese, 1 Indian and 4 English.

24.7900

66886

SOV/126-8-1-2/25

AUTHOR: Kopvillem, U. Kh.

TITLE: On the Effect of Internal Interactions on the Second Moment of the Paramagnetic Resonance Curve in the Case of not Purely Spin Magnetism

PERIODICAL: Fizika metallov i metallovedeniye, 1959, Vol 8, Nr 1, pp 8-16 (USSR)

ABSTRACT: Many authors (Refs 1-7) have calculated the second moment of the paramagnetic absorption curve for magnetically isotropic crystals. However, the results obtained in these papers do not take into account the anisotropy in the g-factor, the dependence of the character of internal interactions on temperature and effects due to the lack of coincidence between the direction of the static magnetic field H_o and the symmetry axis of the internal crystal electric field E. In the present work a calculation is made of the reduced second moment $\langle(\Delta\nu)^2\rangle$ of the paramagnetic resonance curve under the following assumptions:
a) the g-factor is anisotropic;
b) the paramagnetic line-width is due to dipole-dipole $H_{1\partial}$, anisotropic exchange H_{1o6} and hyperfine H_{1cmc}

Card 1/4

interactions;
c) the field H_o has an arbitrary direction relative to the symmetry axes of the crystal;
d) the spin system consists of N magnetically equivalent ions and their ground energy state in the field E has a two-fold Kramers degeneracy,
e) the spin temperature T is sufficiently low so that only the ground doublet is populated;
f) the dependence of the character of the internal interactions on T and E is taken into account.
In the calculations use was made of the fact that the magnetic moment μ_t^k of the ion k in the direction of the axis t can be written in the form (Ref 8) of Eq (1), where $g_{t\ell}$ are the elements of the g-tensor, σ_ℓ are the Pauli matrices and β is the Bohr magneton. As far as the wave functions $\{\psi_{ov}\}$ of the unperturbed spin system are concerned, it is shown that they can easily be found by solving the secular equation for some fictitious

Card 2/4

On the Effect of Internal Interactions on the Second Moment of the Paramagnetic Resonance Curve in the Case of not Purely Spin Magnetism

operator (the spin Hamiltonian H_s) whose eigenvalues fully describe the position of the lines in the paramagnetic resonance spectrum. When $\langle(\Delta\nu)^2\rangle$ is calculated with the aid of the eigenfunctions $\{\psi_{ov}\}$ of the spin Hamiltonian $\underline{H}_s$, the reduced second moment of the paramagnetic resonance curve can be expressed in terms of the coefficients of the spin Hamiltonian, which can be measured to a high degree of accuracy by the paramagnetic resonance method. The corresponding experimental data are given in Refs 4-6. The formula for $\langle(\Delta\nu)^2\rangle$ may be used both to predict the paramagnetic line width and also to study internal interactions in paramagnetics. The latter is of great importance in the selection of substances for paramagnetic amplifiers and microwave generators. It is shown that the field E has a considerable effect on the character of internal interactions in paramagnetics and the symmetry properties of the field E are taken over by $\langle(\Delta\nu)^2\rangle$ through the coefficients of the spin

Card 3/4

On the Effect of Internal Interactions on the Second Moment of the Paramagnetic Resonance Curve in the Case of not Purely Spin Magnetism

Hamiltonian. When the field H_o does not coincide with the principal axes of the g-tensor, an additional anisotropy in the dynamic properties of paramagnetic monocrystals will appear. Exchange interactions contribute to $\langle(\Delta\nu)^2\rangle$ even in the case of a real 1/2 spin and an isotropic g-factor. Quadripole interaction Q^{II} has no effect on $\langle(\Delta\nu)^2\rangle$. $\langle(\Delta\nu)^2\rangle_{cmc}$ is independent of temperature.

Professor S. A. Al'tshuler is thanked for suggesting the subject and his interest in this work.
There are 1 table and 13 references, 2 of which are Soviet and 11 English.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet imeni V.I. Ul'yanova (Kazan State University imeni V.I.Ul'yanov)

SUBMITTED: March 13, 1958 (Initially)
September 16, 1958 (After revision)

Card 4/4

S/058/61/000/010/051/100
A001/A101

24,7900

AUTHOR: Kopvillem, U. Kh.

TITLE: Spin-spin relaxation time at the absence of magnetic field in ethyl sulfates and dinitrates of rare-earth elements at helium temperatures

PERIODICAL: Referativnyy zhurnal. Fizika, no.10, 1961, 165, abstract 10V368 (V sb. "Paramagnitn. rezonans", Kazan', Kazansk. un-t, 1960, 81 - 84)

TEXT: The author derives formulae for calculating the 2nd moment of an aperiodic curve of low-frequency paramagnetic absorption in crystals. Magnetic dipole-dipole and anisotropic exchange interactions are taken into consideration, as well as contributions to the curve width caused by lattice defects and unresolved fine and superfine structures. In this connection, the value of the spin-spin relaxation time in the absence of magnetic field has been determined. It is shown that the shape of the low-frequency absorption line depends strongly on the orientation of polarization of the variable magnetic field, as distinct from the curve of electronic paramagnetic resonance. Particular calculations are

Card 1/2

Spin-spin relaxation time ...

performed for ethyl sulfates and dinitrates of rare-earth ions. In view of strong anisotropy of the g-factor in these substances, the relaxation time is also strongly anisotropic. A method is pointed out for measuring small g-factors and anisotropic exchange interactions by the method of low-frequency paramagnetic absorption.

U. Kopvillem

[Abstracter's note: Complete translation]

Card 2/2

S/058/61/000/010/038/100
A001/A101

24,7900

AUTHORS: Koloskova, N.G., Kopvillem, U. Kh.

TITLE: Even-order moments of the paramagnetic resonance line at strong-magnetic dilution of a crystalline specimen

PERIODICAL: Referativnyy zhurnal, Fizika, no.10, 1961, 160, abstract 10V330 (V sb. "Paramagnitn. rezonans", Kazan', Kazansk. un-t, 1960, 86-89)

TEXT: The authors derive theoretically a formula for calculating, at small concentrations C of magnetic ions in dielectrical crystals, even-order moments in the curve of paramagnetic resonance absorption of magnetic particles with effective spin equal to $\frac{1}{2}$. The formula contains elements of a tensor describing any two-particle spin-spin interactions between magnetic equivalent particles, depending on first powers of spin operators. At an isotropic g-factor, taking into account only magnetic dipole-dipole interactions, the formula coincides with the known result of C. Kittel and E. Abrahams ("Phys. Rev", 1953, v. 91, 894). As an example, 2nd and 4th moments of electronic paramagnetic resonance lines are calculated for rare-earth ions in dinitrates and ethyl sulfates. The authors investigate distribution of spin-spin relaxation times in

Card 1/2

S/058/61/000/010/038/100
A001/A101

Even-order moments ...

clusters of magnetic ions formed during magnetic dilution of a crystal. It is established that in substances under consideration the shape of the electronic paramagnetic resonance curve at C = 1 is almost rectangular. At C→0 the curve is narrowing down in the center and the wings fall off according to the law $C\nu^{-1}$, where ν is frequency distance from the curve center.

U. Kopvillem

[Abstracter's note: Complete translation]

Card 2/2

B/058/61/000/010/035/100
A001/A101

24,7900

AUTHORS: Kopvillem, U.Kh., Mineyeva, R.M., Morozova, I.D.

TITLE: On the theory of the width of the paramagnetic resonance line in corundum with admixture of chromium

PERIODICAL: Referativnyy zhurnal. Fizika, no. 10, 1961, 159, abstract 10V327 (V sb. "Paramagnitn. rezonans", Kazan', Kazansk. un-t, 1960, 92-94)

TEXT: The authors derived a formula for calculating the width of electronic paramagnetic resonance line in magnetic-diluted crystals, due to the presence of dislocations and inner stresses. It is assumed that the spin Hamiltonian of paramagnetic ions contains two parts: the main part is the same for all ions and it determines the spectrum of electronic paramagnetic resonance; the second part characterizes the straggling of constants of the spin Hamiltonian due to straggling of symmetry axes of the crystalline field and it determines the observed width of electronic paramagnetic resonance line. Particular calculations are performed for Cr ions in the lattice of corundum. A comparison of the calculated and experimental data shows that the strong anisotropy of the line width in dependence on direction of the statical magnetic field is explained by

Card 1/2

S/058/61/000/010/035/100
A001/A101

On the theory of the width ...

the contribution from the straggling of symmetry axes of the crystalline field. Contributions to the line width due to interaction of Cr ions between themselves and with Al nuclei are also calculated.

U. Kopvillem

[Abstracter's note: Complete translation]

Card 2/2

S/058/61/000/010/037/100
A001/A101

24,7900

AUTHOR: Kopvillem, U.Kh.

TITLE: The second moment for fine structure components in the curve of paramagnetic resonance on ions with arbitrary effective spin

PERIODICAL: Referativnyy zhurnal.Fizika, no.10, 1961, 159-160, abstract 10V329 (V sb. "Paramagnitn. rezonans", Kazan', Kazansk. un-t, 1960, 94-98)

TEXT: The author derived formulae for calculating the reduced 2nd moment of the electronic paramagnetic resonance curve, pertaining to an individual component of the fine structure. Calculations can be performed by means of wave functions, determined from the spin Hamiltonian of a paramagnetic ion. A case of equivalent and non-equivalent ions, in magnetic respect, is considered. In distinction from the results of M.N.L. Pryce and K.W.H. Stevens ("Proc. Phys. Soc.", 1950, v A63, 36), the formulae take into account the dependence on the Boltzman-factor which determines population of undisturbed energy levels of the spin-system. Moreover, the formulae are written in a form suitable for direct calculations in cases of ions whose Hamiltonian possesses axial symmetry. In case of magnetic dipole-dipole interactions, the fine structure component

Card 1/2

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A001/A101

The second moment for fine structure components ... $\left|\frac{1}{2}\right> \longleftrightarrow \left|-\frac{1}{2}\right>$ possesses the maximum width. With increasing of magnetic quantum number m, which characterizes function $|m\rangle$, the crystalline field reduces the effectiveness of resonance spin-spin interactions and the line of electronic paramagnetic resonance becomes narrower.

U. Kopvillem

[Abstracter's note: Complete translation]

Card 2/2

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S/139/60/000/03/039/045

24.7900

E032/E314

AUTHORS: Koloskova, N.G. and Kopvillem, U.Kh.

TITLE: The Width of the Magnetic Resonance Line in Diluted Paramagnetic Monocrystals with an Anisotropic g-factor

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Fizika, 1960, No 3, pp 223 - 229 (USSR)

ABSTRACT: Kittel and Abrahams and also Glebashev (Ref 1) have obtained formulae for the second and fourth reduced moments $\langle(\Delta\nu)^2\rangle$ and $\langle(\Delta\nu)^4\rangle$ of the paramagnetic resonance curve $f(\nu)$ in non-conducting magnetically diluted monocrystals. However, these authors did not take into account the effect of the internal electric field E on the interactions H_1 between magnetic ions in the crystal. As a result, the formulae obtained in Ref 1 cannot be used in the analysis of experimental curves for $f(\nu)$ and the calculation of the constants characterising the internal interaction in paramagnetics. The present paper is concerned with a spin system consisting of cN magnetically equivalent paramagnetic ions with an effective spin S = 1/2 and

Card1/3

82342
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E032/E314

The Width of the Magnetic Resonance Line in Diluted Paramagnetic Monocrystals with an Anisotropic g-factor

an anisotropic g-factor. The effect of the internal field E on the interaction H_1 is reduced to the derivation of the functional dependence between $f(\nu)$, $\langle(\Delta\nu)^2\rangle$ and $\langle(\Delta\nu)^4\rangle$ on the one hand, and the elements of the g-tensor and the coefficients of the eigenfunctions $|\pm\rangle$ of the paramagnetic ion, on the other. Such a functional dependence can be used to predict the half-width $\Delta\nu_{1/2}$ of paramagnetic resonance lines, to calculate the exchange integrals I^{ik} between magnetic ions i and k and to use the extensive experimental material accumulated by the paramagnetic resonance methods in the study of internal interactions H_1 in paramagnetics. All the internal interactions in paramagnetics which can be written down in the form of a tensor operator depending on the spin variables of two paramagnetic ions, are taken into account. The tensor

Card2/3

82342

S/139/60/000/03/039/045
E032/E314

The Width of the Magnetic Resonance Line in Diluted Paramagnetic Monocrystals with an Anisotropic g-factor

operators for dipole-dipole and anisotropic exchange interactions are taken as an example. The theory is used to calculate $\Delta\nu_{1/2}$ for the Nd^{3+} ion in $(La(C_2H_5SO_4)_3 \cdot 9H_2O$. It is found that in this case (Ref 4) $\Delta\nu_{1/2} \sim 15$ Oe, which is in good agreement with experiments. This shows that $\Delta\nu_{1/2}$ is entirely due to magnetic dipole-dipole interactions between Nd^{3+} ions. There are 1 table and 7 references, 4 of which are English and 3 Soviet.

ASSOCIATION: Kazanskiy gosuniversitet imeni V.I. Ul'yanova-Lenina (Kazan State University imeni V.I. Ul'yanov-Lenin)

SUBMITTED: July 6, 1959

Card 3/3

KOPVILLEM, U. Kh.

82510

S/181/60/002/007/002/042
B006/B070

24.7900

AUTHORS: Koloskova, N. G., Kopvillem, U. Kh.

TITLE: Effect of the Inner Electric Field in Non-conducting Paramagnetic Single Crystals on Two-particle Spin-Spin Interaction

PERIODICAL: Fizika tverdogo tela, 1960, Vol. 2, No. 7, pp. 1368-1378

TEXT: The purpose of the present work is to calculate the second and fourth moments of the distribution curve of the off-diagonal elements of the spin-spin interaction operator. The calculation is made by taking into consideration the coefficients of the spin Hamiltonian of the dipole - dipole and the anisotropic exchange interactions between the ions with an anisotropic g-factor and the effective electron spin 1/2. The results of the theoretical investigation are applied to a study of the shape of the paramagnetic resonance line and of the free magnetic induction. The relaxation process in a spin system is examined on the basis of Bloch's theory, and the order of magnitude of the paramagnetic

Card 1/3

82530

Effect of the Inner Electric Field in Non-conducting Paramagnetic Single Crystals on Two-particle Spin-Spin Interaction

S/181/60/002/007/002/042
B006/B070

ASSOCIATION: Kazanskiy gosudarstvennyy universitet imeni V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin)

SUBMITTED: March 4, 1959

Card 3/3

82999

S/181/60/002/008/018/045
B006/B070

24.7900

AUTHOR: Kopvillem, U. Kh.

TITLE: Theory of Cross Relaxation on Magnetically Dilute Crystals

PERIODICAL: Fizika tverdogo tela, 1960, Vol. 2, No. 8, pp. 1829-1834

TEXT: The purpose of the present work is to derive formulas for the calculation of the probability of transitions due to cross relaxation, taking into account the single-particle and two-particle spin-spin interactions of arbitrary type in magnetically dilute diamagnetic crystals. The crystals are assumed to consist of magnetic ions of the type α which are distributed at random in the crystal lattice. $C_\alpha \ll 1$ holds for their concentration, C_α. The general theoretical results are applied to estimate the order of magnitude of the paramagnetic cross relaxation time in corundum that contains Cr^{3+} ions. For three different Cr^{3+} ion concentrations, namely, $C = 14.10^{-5}$, $C = 39.10^{-4}$, and $C = 5.10^{-3}$ ions in Al_2O_3, the following times were obtained: 61, 14, and $\ll 14\mu$sec. The results, obtained by the use of a very large number of formulas,

Card 1/2

82999

Theory of Cross Relaxation on Magnetically Dilute Crystals

S/181/60/002/008/018/045
B006/B070

most of which are not derived, and by assuming the notation and results from a large number of appropriate publications, are briefly discussed. There are 16 references: 6 Soviet, 9 US, and 1 British.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet imeni V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin)

SUBMITTED: December 30, 1959

Card 2/2

86867

S/141/60/003/005/022/026
E192/E382

6.8000 (3201, 1099, 1162, 1144)

AUTHORS: Koloskova, N.G. and Kopvillem, U.Kh

TITLE: The Possibility of Exciting Free Nuclear Induction by an Ultrasonic Pulse

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, 1960, Vol. 3, No. 5, pp. 904 - 905

TEXT: The possibility of using an ultrasonic pulse for exciting the spin system of a paramagnetic material is investigated. It is assumed that a longitudinal sound wave propagates along the crystal axis (110) of a cylindrical sample of a crystal with a cubic lattice. The sample contains N identical magnetic nuclei having an electric quadrupole moment Q. The directions z and y are determined by the spherical coordinates Θ, φ and $3\pi/2 + \Theta$ φ where (110) is the polar axis and φ is the azimuthal angle measured from (001). It is assumed that the times of the transverse and longitudinal magnetic relaxation (T_2 and T_1) and the transient time of the

Card 1/5

86867

S/141/60/003/005/022/026
E192/E382

The Possibility of Exciting Free Nuclear Induction by an Ultrasonic Pulse

standing sound waves in the crystal (t_v) fulfil the condition T_1, $T_2 \gg t_v$ and $\Delta t \gg 2\pi/\omega_o$, where $\omega_o = \gamma H_o$ is the Larmor precession of the spins s in a strong static magnetic field H_o and γ is the gyromagnetic ratio. The equations of motion for the macroscopic components of magnetisation along the axes x, y, z under the influence of an ultrasonic pulse having a duration Δt and carrier frequency $n\omega_o$ for $s = 3/2$ are as follows:

Card 2/5

S/141/60/003/005/022/026
E192/E382

The Possibility of Exciting Free Nuclear Induction by an Ultrasonic Pulse

$$\langle \mu \rangle_1 = \frac{\sqrt{3}\, N\gamma\hbar\zeta}{4}\left\{\zeta \sin\left(2\sqrt{3}\,\omega_1\Delta t\right)\left[x\cos\left(\omega_0 t\right) - y\sin\left(\omega_0 t\right)\right] + \right.$$
$$\left. + \frac{1}{\sqrt{3}}\left[\cos\left(2\sqrt{3}\,\omega_1\Delta t\right) + 4\right] z\right\} \qquad (\zeta = \gamma\hbar/I_0 kT); \tag{1}$$

$$\langle \mu \rangle_2 = N\gamma\hbar\zeta\left[\cos\left(2\sqrt{3}\,\omega_2\Delta t\right) + 1\right] z;$$
$$\omega_1 = [-16s(2s-1)\hbar]^{-1} 9eQ(1-\gamma_\infty) C_{11}\sin(2\theta) E_{01};$$
$$\omega_2 = [-8s(2s-1)\hbar]^{-1} eQ(1-\gamma_\infty)\left[\frac{3}{4} + \frac{C_{11}}{C_{11}}\right] C_{11} E_{02}; \tag{2}$$
$$E_{0n} \sim \frac{n\omega_n \rho}{v}; \quad W_n = \frac{1}{2} v \rho E_{0n}^2.$$

In the equations W_n is the power of the sonic wave per cm^2, ρ is the density of the crystal, v is the velocity of propagation of the longitudinal sonic wave,

Card 3/3

86867

S/141/60/003/005/022/026
E192/E382

The Possibility of Exciting Free Nuclear Induction by an Ultrasonic Pulse

A_o is the displacement of the base of the cylinder, C_{11} and C_4 are the elements of the tensor relating the gradient of the electric field in the nuclei to the deformation tensor, γ_∞ is the anti-screening constant and $\underline{x}$, $\underline{y}$, $\underline{z}$ are unit vectors. It is seen that the x- and y-components of the macroscopic vector $\underline{\mu}$ will oscillate at a frequency ω when the ultrasonic generator is switched off. The calculations for the nuclei Br^{79} in the crystal of KBr showed that the strength of the signal determined by Eq. (1) was equal to the strength of the normal signal of the nuclear inductance at room temperature if $T \sim 1.4\ ^{o}K$ and $H \sim 10^4$ gauss. The ultrasonic pulse

Card 4/5

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S/126/60/009/05/002/025
E032/E514

24.7900
AUTHOR: Kopvillem, U. Kh.

TITLE: The Fourth Moment for the Fine Structure Components of the Nuclear and Electron Paramagnetic Resonance Line in Magnetically Dilute Crystals

PERIODICAL: Fizika metallov i metallovedeniye, 1960, Vol 9, No 5, pp 657-661 (USSR)

ABSTRACT: Van Vleck (Ref 1, Eq (21)) has derived a formula for the reduced fourth moment $\langle(\Delta\nu)^4\rangle$ of the magnetic resonance line in magnetically isotropic crystals in the absence of an intercrystalline electric field E. Subsequently, Kittel and Abrahams (Ref 2) and Glebashev (Ref 3) took into account the concentration c of magnetic particles in the specimen on the quantity $\langle(\Delta\nu)^4\rangle$ due to magnetic dipole-dipole and exchange interactions. Since magnetic particles in crystals are always affected by the field E, none of the formulae obtained so far for the fourth moment can be used in a quantitative comparison of experimental and theoretical data on the form $f(\nu)$ of the resonance line. The

Card 1/4

S/126/60/009/05/002/025
E032/E514

The Fourth Moment for the Fine Structure Components of the Nuclear and Electron Paramagnetic Resonance Line in Magnetically Dilute Crystals

present paper is concerned with the derivation of a formula for the fourth moment $\langle (\Delta\nu)^4 \rangle$ taking into account c, E and the Boltzmann factor. The case under consideration is that when N_{jc}, N_ℓ and N_r of the total number L of sites in a diamagnetic monocrystal are respectively occupied by paramagnetic particles of types (i,j), ℓ and r which are distributed over the specimen in an unordered fashion and, moreover, $N_a L^{-1} = c_a \ll 1$, where a = j, ℓ, r. Particles of type (i,j) and ℓ have different paramagnetic resonance frequencies, while particles of types (i,j) and r have the same spin ($S^j = S^r$) but are placed on sites for which the symmetry axes of the field E have the same direction but the field constants are different in magnitude. This case is taken into account in Eq (12) and refers to the fine

Card 2/4

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E032/E514

The Fourth Moment for the Fine Structure Components of the Nuclear and Electron Paramagnetic Resonance Line in Magnetically Dilute Crystals

structure component due to the transition $\left|S^r, \frac{1}{2}\right\rangle \leftrightarrow \left|S^r - \frac{1}{2}\right\rangle$.

The Hamiltonian for the spin system is taken to be in the form given by Eq (1), where $a = j, \ell, r$, $\underline{H}_o$ is the Hamiltonian of the unperturbed spin-system, $\underline{H}_1$ is the perturbation, $\underline{H}_3^a$ and $\underline{H}_e^a$ are the Zeeman and Stark energy operators of the particle a in static magnetic and electric fields H_o and E, respectively, S_α^a are the components of the effective spin vector of the particle a, and $p_{\alpha\beta}^{ia}$ are the components of the tensor characterizing two-particle spin-spin interactions between magnetic particles i and a (Kopvillem, Ref 4). It is shown that the ratio $\langle(\Delta\nu)^4\rangle / \langle(\Delta\nu)^2\rangle^2$ increases with decreasing temperature, which can be interpreted as a contraction of the central part of the line. Other things being equal, the quantity $\langle(\Delta\nu)^4\rangle$ for the fine

Card 3/4

24.7900(1035, 1144, 1160)

S/126/60/010/006/003/022
E201/E491

AUTHORS: Koloskova, N.G. and Kopvillem, U.Kh.

TITLE: Acoustic Excitation of Free Nuclear Induction in Cubic Crystals

PERIODICAL: Fizika metallov i metallovedeniye, 1960, Vol.10, No.6, pp.818-824

TEXT: Acoustic magnetic resonance was discussed first theoretically by Al'tshuler (Ref.1). Later it was found experimentally in magnetic nuclei and electron shells of atoms (Ref.2). The acoustic method is now widely used to study the spin-lattice interactions H_{cp}. The present authors show that the existing ultrasonic pulse method (Ref.3) can be used to measure the interaction H_{cp} independently of the value of the form-factor $g(\nu)$. This is done by recording the intensity I of a nuclear induction signal produced by sound pulses. The form of the signal gives information on the nature of non-equilibrium components of the magnetic and quadrupole moments of the spin system. The authors' calculations deal with the specific case of cubic crystals containing identical magnetic nuclei possessing electric quadrupole moments. The intensity and form of the signal are

Card 1/2

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E201/E491

Acoustic Excitation of Free Nuclear Induction in Cubic Crystals

calculated. It is shown that an acoustic pulse causes oscillations of the non-equilibrium macroscopic components of the electric quadrupole moment tensor of the spin system.
Acknowledgments are made to S.A.Al'tshuler, R.A.Dautov and B.I.Kochelayev for their advice. The paper is entirely theoretical. There are 13 references: 4 Soviet and 9 non-Soviet (one of which is translated into Russian).

ASSOCIATION: Kazanskiy gosudarstvennyy universitet
(Kazan State University)

SUBMITTED: May 16, 1960

Card 2/2

KOPVILLEM, U.Kh.

Second [redacted] the paramagnetic absorption line with allowance for fine and hyperfine structure. Zhur. eksp. i teor. fiz. 38 no.1:151-156 Jan '60. (MIRA 14:9)

1. Kazanskiy gosudarstvennyy universitet.
(Paramagnetic resonance and relaxation)

83753

S/056/60/038/004/046/048
B006/B056

24.1800

AUTHORS: Koloskova, N. G., Kopvillem, U. Kh.

TITLE: The Shape of the Lines of Nuclear Acoustic Resonance

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 38, No. 4, pp. 1351 - 1353

TEXT: Within the framework of the quantum theory of irreversible processes, the authors investigated the character of the interaction between an ultrasonic field and a nuclear spin system in a cubic crystal, and showed that the experimental data on acoustic magnetic resonance (acoustic resonance absorption, relaxation processes in acoustically excited spin systems) cannot be satisfactorily described by means of the theory of nuclear magnetic resonance (Refs. 1,2). For the shape $A(\omega)$ of acoustic resonance absorption lines, a formula (1) is given, which holds for the case in which a longitudinal sound wave penetrates the crystal in the [110] direction, and a strong static magnetic field $\vec{H} \parallel z$ forms the angle θ together with the [110] axis. According to this formula, the absorption curve $A(\omega)$ consists of a number of Gaussian lines which are

Card 1/2

26025

24.2200

S/139/61/000/003/005/013
E202/E335

AUTHOR: Kopvillem, U.Kh.

TITLE: Paramagnetic Cross Relaxation in Crystals with Anisotropic g-Factors

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Fizika, 1961, No. 3, pp. 50 - 55

TEXT: Considering the strong effect which the ion concentration of paramagnetic particles in a diamagnetic single crystal has on the change in the population of the energy levels of a non-perturbed spin system of a paramagnetic exposed to an alternating magnetic field, the author develops relationships between the probability of the relaxation transitions in unit time, the time of relaxation, and the anisotropy of the g-factor and the lattice structure formed by the magnetic ions randomly distributed within the diamagnetic crystal. The resulting formulae for the calculation of cross-relaxation time in a diamagnetic crystal containing traces of paramagnetic materials showed that at helium temperatures the process of spin-lattice relaxations is preceded by the transfer

Card 1/3

2625

Paramagnetic Cross Relaxation ... S/139/61/000/003/005/013
E202/E335

ASSOCIATION: Kazanskiy gosuniversitet
(Kazan State University)

SUBMITTED: April 20, 1960

Card 3/3

32217
S/139/61/000/004/007/023
E032/E314

24,7000 (1136, 1144, 1385)

AUTHORS: Koloskova, N.G. and Kopvillem, U.Kh.

TITLE: Ultrasonic nuclear induction in dielectric crystals

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Fizika, no. 4, 1961, 48 - 51

TEXT: The spin-echo method is being widely used in the study of paramagnetic spin systems (Ref. 1: I.J. Lowe, R.E. Norberg. Phys. Rev., 107, 46, 1957). The aim of the present paper is to investigate the possible application of various pulse generators to the excitation of paramagnetic spin systems in crystals, e.g. light sources, ultrasonic generators, cold neutrons, variable magnetic fields and so on. If the operator H_2, which represents the contribution of the pulse generator to the Hamiltonian of the spin system does not commute with the magnetic and electric quadrupole moment operators of the spin system (μ and Q) and, moreover, the generator produces sufficient power and the duration of the pulse is much smaller than the relaxation times T_k of the non-equilibrium components μ and Q,

Card 1/3

Ultrasonic nuclear induction ....

then the pulse method may be used to measure the dynamic characteristics of the spin system, i.e. the times T_k and the magnitudes of the matrix elements $\langle k|H_2|\ell\rangle$ (the constant of interaction between the magnetic particles of the pulse generator). The authors discuss the case where the "instrument" is a spin system with an axial symmetry, while the "scale of the instrument" gives Δt and the average value $\langle \mu_z(\Delta t)\rangle$ of the z-component of the magnetic moment of the spin system. It is shown that in the case of ultrasonic excitation these data can be used to determine the matrix element of the nuclear spin-lattice interaction operator in crystals. A quantum theory of the indications of the "instrument" is developed for the case where the generator interacts with each magnetic particle separately. The paper is concluded with a discussion of the possible detection of free nuclear precession in cubic crystals excited by an ultrasonic pulse.

4

Card 2/3

32217
S/139/61/000/004/007/023
E032/E314

Ultrasonic nuclear induction ....

There are 5 references: 4 Soviet-bloc and 1 non-Soviet-bloc. The English-language reference mentioned is quoted in the text.

ASSOCIATION: Kazanskiy gosuniversitet imeni V.I. Ul'yanova-Lenina (Kazan' State University imeni V.I. Ul'yanov-Lenin)

SUBMITTED: July 26, 1960

Card 3/3

20785
S/181/61/003/003/010/030
B102/B214

24,7900 (1144,1153,1136,1155)

AUTHOR: Kopvillem, U. Kh.

TITLE: The possibility of observing the fine structure of electronic and nuclear spin echo

PERIODICAL: Fizika tverdogo tela, v. 3, no. 3, 1961, 754-756

TEXT: The spin echo method is very common for the measurement of times T_2 and T_1 of phase and thermal nuclear magnetic relaxations in cubic crystals. The present paper gives formulas for the calculation of the initial intensity and the form of the signal of the free magnetic precession and the spin echo caused by transitions related to a certain allowed fine-structure component of the spectrum of nuclear or electronic magnetic resonance. Further, a method for measuring the characteristic parameters of the lines of each fine-structure component of the magnetic resonance spectrum is discussed. The spin system is described by the Hamiltonian $\mathcal{H} = \mathcal{H}_0 + \mathcal{H}_1$; $\mathcal{H}_0 = \sum_j (\mathcal{H}_Z^j + \mathcal{H}_E^j)$; $\mathcal{H}_1 = \mathcal{H}_{ss} + \mathcal{H}_{sl}$, where $\mathcal{H}_0$ is the Hamiltonian of the unperturbed system having

Card 1/5

The possibility of ...

axial symmetry with respect to the z-axis; $\mathcal{H}_1$ is the perturbation caused by spin-spin ($\mathcal{H}_{ss}$) and spin-lattice ($\mathcal{H}_{sl}$) interaction; $\mathcal{H}_{ss}$, $\mathcal{H}_{sl}$; $\mathcal{H}_z^j$ and $\mathcal{H}_E^j$ are the operators of the Zeeman and Stark energy of the jth particle in the static magnetic field $H_0 \| z$ and in the E-field, respectively. It is assumed that no equidistant pairs of energy levels appear in the spectrum of a single particle, and that the field H_1 rotates in the xy plane with the angular frequency $\omega_{kl} = \hbar^{-1}(E_k - E_l)$, where E_k and E_l are energy-level pairs with the eigenfunctions $|k = m+1\rangle$ and $|l = m\rangle$; m is the magnetic quantum number. At the time t=0, the temperature of the spin system is equal to T; the duration of the r. f. pulses acting on the sample is $t_w \ll T_1, T_2$. Using the formulas for the density matrix, formulas are obtained for the calculation of the mean value $\langle \mu(t) \rangle_{kl}$ of the magnetic moment $\mu(t)$ of the spin system, the time t being reckoned from the instant the pulse is cut off. The formula is:

Card 2/5

The possibility of ...

$$\langle\mu(t)\rangle_{kl} = \varkappa\{\langle\mu(0)\rangle + \langle\mu(0)\rangle_{kl}[\cos(2\langle k|S_x|l\rangle\omega t_w) - 1]f_1(t)\} +$$
$$+ f_2(t)\{2\langle k|S_x|l\rangle\langle\mu(0)\rangle_{kl}\sin(2\langle k|S_x|l\rangle\omega t_w)\}\times$$
$$\times\{\mathbf{x}\sin[\omega_{kl}(t_w + t)] - \mathbf{y}\cos[\omega_{kl}(t + t_w)]\}, \quad (2)$$

$$\langle\mu(0)\rangle = Ng_{\parallel}\beta\left(\sum_r A_r m_r\right)\left(\sum_r A_r\right)^{-1}, \quad \omega = \hbar^{-1}g_{\perp}\beta H_1, \quad A_k = \exp\left(-\frac{E_k}{kT}\right),$$

$$\langle\mu(0)\rangle_{kl} = Ng_{\parallel}\beta\left[\frac{1}{2}(A_l - A_k)\right]\left[\sum_r A_r\right]^{-1},$$

Here, N is the number of magnetic particles, β is the Bohr magneton, $g_{\parallel}$ and $g_{\perp}$ are the spectroscopic splitting factors, k is Boltzmann's constant, $\vec{x}$, $\vec{y}$, and $\vec{z}$ are unit vectors, and $\langle k|S_x|l\rangle$ is the matrix element of the operator S_x. The law of fading of the nonequilibrium components of the vector $\langle\mu(t)\rangle_{kl}$ is given by the correlation functions $f_1(t)$ and $f_2(t)$. If the form factor $g(\omega_{kl})$ is a Gaussian or Lorentz function, then $f_2(t) = \exp(-t^2\langle(\Delta\nu)^2\rangle_{kl}/2$, and $f_2(t)_{1/2} = \exp(-\Delta t)$, respectively, where $\Delta = (2\alpha)^{-1}\pi\langle(\Delta\nu)^2\rangle_{kl}$ and

Card 3/5

The possibility of ...

$\alpha = \left[\frac{3\langle(\Delta\nu)^4\rangle_{kl}}{\langle(\Delta\nu)^2\rangle_{kl}}\right]$. The initial value of the amplitude of the signal of the free magnetic precession is given by $\langle\mu(t=0)\rangle_{kl}$, where $2\langle k|S_x|l\rangle\omega t_w = \pi/2$. The amplitude of the spin-echo signal is determined by the value of $\langle\mu(t')\rangle_{kl}$ in the xy plane. For a large dislocation density in the crystal, only the spin-echo signal can be observed; the electron spin echo can be observed at helium temperatures in crystals which have no magnetic nuclei. In this case, the $g(\omega_{kl})$ curves may also be studied by the pulse method using the relation between $g(\omega_{kl})$ and $f_2(t)$. The function $f_1(t)$ is determined by $\varkappa_{sl}$ and the cross relaxation processes; for studying these interactions, the z-component of $\langle\mu(t)\rangle_{kl}$ must be twisted in the xy plane by the secondary. If S = 1/2 is substituted in (2), the known result of I. J. Lowe and R. E. Norberg (Phys. Rev. 107, 46, 1957) is obtained, which holds when E = 0. There are 6 references: 4 Soviet-bloc and 2 non-Soviet-bloc.

Card 4/5

20785

The possibility of ... S/181/61/003/003/010/030
B102/B214

ASSOCIATION: Kazanskiy gosudarstvennyy universitet im. V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin)

SUBMITTED: June 18, 1960

X

Card 5/5

KOPVILLEM U.Kh.

Harmonic corss-relaxation in crystals. Fiz.tver.tela 3 no.4: 1190-1194 Ap '61. (MIRA 14:4)

1. Kazanskiy gosudarstvennyy universitet imeni V.I.Ul'yanova-Lenina. (Paramagnetic resonance and relaxation)

25688
S/181/61/003/007/010/023
B102/B214

24,7900

AUTHORS: Kopvillem, U. Kh., and Korepanov, V. D.

TITLE: The appearance of hypersonics on saturation of paramagnetic resonance in crystals

PERIODICAL: Fizika tverdogo tela, v. 3, no. 7, 1961, 2014-2022

TEXT: On saturation of paramagnetic resonance in crystals the population difference $\Delta n_{ab}=n_a-n_b$ of an energy-level pair ($E_a<E_b$) of magnetic ions can become negative. If a weak variable magnetic field of amplitude H and frequency $\omega_{ba}=\hbar^{-1}(E_b-E_a)$ acts on this crystal, a radiation (photon production on account of magnon annihilation) is induced, which exceeds the induced absorption. Thus, the magnetic field is amplified, or a variable electromagnetic field is generated if there exists no external H field. Theoretical investigations of S. A. Al'tshuler (ZHETF, 28, 38, 49, 1955) as well as experimental studies show that on excitation of a paramagnetic crystal by hypersonics of frequency ω_{ba} and amplitude A,

Card 1/6

The appearance of hypersonics ...

there occurs a forced production and annihilation of magnons and phonons (instead of the photons). What has been said above holds if only one says "phonon" instead of "photon" and "A" instead of "H" (A - amplitude of lattice vibrations). If magnetic as well as hypersonic excitation exists, there take place different interference effects in the crystal, which can be used for the indication of electromagnetic and sound fields. The object of the theoretical investigations described here was to classify the effect and estimate its order of magnitude. A nonequilibrium state of a spin system, caused by the saturation of paramagnetic resonance is considered, where the self-excitation of hypersonics in the crystal is possible at the cost of the energy of an alternating field. Parameters are introduced by which the conditions for the appearance of the reversepiezo-magnetic effect can be determined. Taking into account the existing theories and the experimental results on acoustic magnetic resonance and on the change of constants of the crystal field by pressure, the piezo-magnetic parameters of a number of crystals including electronic, nuclear, and mixed spin systems are estimated. The values obtained for the sound quality factor Q_3 are given in a table. Q_3 is defined by $Q_3 = [FC]^{-1}\omega_{ba} = [2\lambda_j'']^{-1}\rho\omega_{ba}^2$, where

Card 2/6

The appearance of hypersonics ...

ρ is the crystal density, C the sonic velocity in the crystal in the x-direction, and F is the spund-absorption coefficient of the spin H system. Further, Q_3=constant $\frac{T\Delta}{\theta\nu}$ for S>1/2, and Q_3=constant $\frac{T\Delta}{\theta\nu^3}$ for S'=1/2 and for rare-earth ions. The quantum-mechanical "temperature", T, for level pairs is determined from the relation $\Delta n_{ab}/(n_a+n_b)=\text{th}(h\nu_{ba}/kT)$. S is the effective spin of the paramagnetic ion, Δ is the half-width of the line in frequency units, and θ is the concentration of magnetic ions in the crystal. At the present level of experimental technique, hypersonics can be excited as a result of interaction between crystal lattice and electronic or nuclear spin in magnetic ions. Finally, the indication of electromagnetic and sound fields by means of interference phenomena is briefly discussed. First of all, the production of hypersonics having frequencies $>10^{10}$ cps is discussed. Using a klystron with $\nu\sim10^{11}$ cps and the harmonic cross relaxation, a negative population difference ($|E_a-E_b|\sim3h\nu$) can be created on the levels and sound of the corresponding frequency generated. The change of the amplification factor of the amplitude H on the levels

Card 3/6

The appearance of hypersonics ...

E_a and E_b due to self-excitation is used for the indication of hypersonics. The reverse process is analogously used for the indication of the electromagnetic field. The authors thank S. A. Al'tshuler for a discussion. There are 1 table and 28 references: 9 Soviet-bloc and 19 non-Soviet-bloc. The most important references to English-language publications read as follows: N. Bloembergen. Phys. Rev., 104, 324, 1956; M.W.P.Strandberg. Phys. Rev. 111, 1268, 1958; E. H. Jacobsen et al. Phys. Rev. Lett., 3, 81, 1959.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet im. V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin)

SUBMITTED: February 10, 1961

26420
S/056/61/041/001/015/021
B102/B214

24.1800 (1137, 1144, 1482)

AUTHORS: Kopvillem, U. Kh., Korepanov, V. D.

TITLE: The possibility of generation and amplification of ultrasonics in paramagnetic crystals

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 1(7), 1961, 211-213

TEXT: In this paper the interaction between a nonequilibrium paramagnetic spin system and crystal lattice is investigated theoretically; the conditions in which the spin-lattice interaction leads to the excitation or amplification of ultrasonics in crystals are studied. The authors start from the theory of S. A. Al'tshuler (ZhETF, 28, 38, 49, 1955) which has been verified experimentally (E.H.Jacobsen et al. Phys. Rev.Lett., 3, 81, 1959). According to this theory phonons can be produced or annihilated in paramagnetic crystals under the action of ultrasonics of frequency $\nu_{ba} = (E_b - E_a)/h \sim 10^{10}$ cps on account of annihilation and production of magnons. The operator describing the interaction of the

Card 1/4

magnetic ion i with the variable magnetic field (R=H) and the sonic field is:

$$\mathcal{H}_1 = \cos(\omega_{ba} t)\, R \sum_{i=1}^{N} [\langle a|\mathcal{P}^{(i)}|b\rangle + \langle b|\mathcal{P}^{(i)}|a\rangle] \qquad (3)$$

Here t is time, R amplitude, $R\langle a|\mathcal{P}^{i}|b\rangle$ the matrix element of the transition of ion i between the states $\langle a|$ and $|b\rangle$ under the action of the perturbation $\mathcal{H}_1$. The imaginary part of the susceptibility and the quality factor of the crystalline sound generator are given by:

$$\chi_R'' = (2\hbar V)^{-1} \Delta n_{ab} |\langle a|\mathcal{P}^{(i)}|b\rangle|^2 g(\nu_{ba}),$$
$$Q_H = (4\pi\chi_H''\eta)^{-1}, \quad Q_A = \omega_{ba}^{-1} Fc = (2\chi_A''\eta)^{-1} \rho\omega_{ba}^2, \qquad (4),$$

where η is the population factor, F the sound absorption coefficient, ρ the crystal density, c the velocity of sound in the crystal, $g(\nu_{ba})$ the normalized form factor of the absorption curve of the magnetic or acoustic energy due to the spin system, and V the volume of the crystal. Q_A is estimated for a Ni^{2+} ion in $NiSiF_6 \cdot H_2O$ in the presence of a static field

Card 2/4

H_0 perpendicular to the symmetry axis (z) of the crystal. One obtains:

$$Q_A \sim T(2S+1)\, k\rho\Delta c_z^2 |2\pi\nu_{ba} N^* a_{33}^2 |\langle a|S_z^2|b\rangle|^2|^{-1} (\partial D/\partial X_{zz})^{-2} = 6{,}38 \cdot 10^{11}\, T/\nu_{ba}, \quad (5)$$

where k is the Boltzmann constant, N^* the number of Ni^{2+} ions per cm^3, S the spin, Δ the width of the line of magnetoacoustic resonance, α_{33} the elastic constant, and T the temperature. The following constants are computed:

$$c_z^2 = 2.5 \cdot 10^{11}\ (cm/sec)^2,\quad N^* = 4 \cdot 20^{21},\quad \rho = 2.08\ g/cm^3$$

$$\alpha_{33} = 0.5 \cdot 10^{12}\ dyne/cm^2,\quad \Delta = 3.2 \cdot 10^9\ cps,$$

$\partial D/\partial X_{zz} = -3.37 \cdot 10^{-26}\ erg.cm^2/dyne$, $|\langle a|S_z^2|b\rangle|^2 = 10^{-1}$.

The Ni-Ni distance in the lattice is assumed to be 6.27 Å. For T = 1°K and $\nu_{ba} = 10^{10}$ cps one obtains $Q_A \approx 63.8$. A significantly smaller value is obtained for Cr ions. To illustrate the above, some possible models of ultrasonic generators and amplifiers working with $NiSiF_6 \cdot 6H_2O$ are

Card 3/4

The possibility of generation and ...

discussed when H_0 is parallel to the trigonal crystal axis (z). Calculations show that in many cases it is easier to realize the conditions for phonon production than those of photon production at the expense of the energy of the spin system. The possibility of the use of nonequilibrium spin system for the detection of acoustic or electromagnetic signals is also discussed. This is accomplished by the method of doubled magneto-ultrasonic resonance in the presence of a strong variable magnetic field. The authors thank S. A. Al'tshuler for discussions. There are 6 references: 2 Soviet-bloc and 4 non-Soviet-bloc.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet (Kazan' State University)

SUBMITTED: January 31, 1961

Card 4/4

24.7000

36480
S/181/62/004/003/021/045
B125/B108

AUTHORS: Koloskova, N. G., and Kopvillem, U. Kh.

TITLE: Theory of the shape of the nuclear acoustic resonance line in cubic crystals

PERIODICAL: Fizika tverdogo tela, v. 4, no. 3, 1962, 697-699

TEXT: The form $A(\omega)$ of the magneto-acoustic resonance line in cubic crystals (the Hamiltonian of which is $\mathcal{H} = \mathcal{H}_0 + \mathcal{H}_1$, $\mathcal{H}_1 = \mathcal{H}_{11} + \mathcal{H}_{12}$) has been studied in the quantum-mechanical theory of irreversible processes. Here, $\mathcal{H}_0$ is the operator of the Zeeman nuclear energy, $\mathcal{H}_{11}$ the operator of two-particle spin-spin interactions; $\mathcal{H}_{12}$ the operator of the quadrupole nuclear energy caused by dislocations in the crystal. The longitudinal sound wave is assumed to propagate along the (110) axis. For transitions with $\Delta m = +2$, Z was assumed to be perpendicular to the (110) axis. If the contribution of the satellite lines is neglected, then

Card 1/3

interaction in crystals. S. A. Al'tshuler is thanked for discussions. There are 10 references: 3 Soviet and 7 non-Soviet. The four most recent references to English-language publications read as follows: W. G. Proctor, W. H. Gentilla, Phys. Rev., 101, 1757, 1956. M. Menes, D. I. Bolef. Phys. Rev., 109, 218, 1958; R. Loudon. Phys. Rev., 119, 919, 1960; E. Otsuka, J. Phys. Soc. Japan, 13, 1155, 1958; E. F. Taylor, N. Bloembergen, Phys. Rev., 113, 431, 1959.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet (Kazan' State University)

SUBMITTED: November 9, 1961

Card 3/3

KOPVILLEM, U.Kh.; SHUBINA, R.V.

Feasibility of absolute polarization of magnetic nuclei by the pulse method. Fiz.tver.tela 4 no.7:1717-1727 Jl '62. (MIRA 16:6)

1. Kazanskiy filial AN SSSR.
(Magnetic fields) (Nuclear spin)

KESSEL', A.R.; KOPVILLEM, U.Kh.

Quantum phonon counter. Fiz. tver. tela 4 no.8:2283-2286 Ag '62. (MIRA 15:11)

1. Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR.
(Electroacoustics) (Quantum theory)

S/181/62/004/011/045/049
B108/B186

AUTHORS: Bashkirov, Sh. Sh., and Kopvillem, U. Kh.

TITLE: Spin-spin interaction between the nuclei of paramagnetic ions through the phonon field

PERIODICAL: Fizika tverdogo tela, v. 4, no. 11, 1962, 3340-3342

TEXT: It is shown that at very low concentrations ($C \ll 1$) of the magnetic centers an exchange between nuclear spins is possible via virtual phonons in dielectric paramagnetic crystals also. The interaction is assumed to be materialized by the annihilation and production of magnons, accompanied respectively by the emission of phonons from the magnetic ions and the absorption of phonons on them. This production and annihilation of magnons can be materialized by (1) transition of the nucleus between hyperfine sublevels of the magnetic ion and (2) mutual reorientation of the nuclear (I) and electron spins (S). An interaction of the type (2) is likely to be weak in paramagnetic substances. In case (1), where the interaction of the nuclear spin with the lattice goes through a hyperfine interaction of the nucleus with the electron and through spin-orbit coupling, the intensity of the exchange interaction decreases as $1/R^3$ (R is the distance

Card 1/2

Spin-spin interaction between i...

S/181/62/004/011/045/049
B108/B186

between two magnetic ions). It is a dipole-dipole interaction with respect to the nuclear spin, and a multipole-multipole interaction with respect to the electron spin. There is 1 table.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet im. V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin); Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR (Physicotechnical Institute of the Kazan' Branch AS USSR)

SUBMITTED: July 16, 1962

Card 2/2

S/126/62/013/005/002/031
E032/E514

AUTHORS: Kopvillem, U.Kh. and Mineyeva, R.M.

TITLE: Free nuclear induction in the absence of a magnetic field

PERIODICAL: Fizika metallov i metallovedeniye, v.13, no.5, 1962, 653-657

TEXT: The method of steady state magnetic and ultrasonic spectroscopy, which involves the determination of the spectrum of resonance absorption by the spin system of the high-frequency magnetic and ultrasonic field, suffers from the disadvantage that the absorption spectrum depends on combinations of the spin-system parameters in a complicated fashion and provides no information on short-lived excited states. The present paper is concerned with the possible application of pulsed generators in magnetic and ultrasonic spectroscopy. In this method the spin-system is brought into an excited state during an interval of time which is sufficiently short so that the magnetic particles do not succeed in interacting with each other and their environment. The generator is then switched off and the average values of the quantities characterizing the substance are measured, e.g. the

components of the magnetic or electric quadrupole moments of the spin system. A particular feature of the pulse method is that it may be possible to neglect the effect of internal interactions on the experimental results. The only limitation is the requirement that the Hamiltonian representing the interaction of the spin-system with the generator should take the form of a sum of single-particle operators for the magnetic particles. A theoretical analysis of the magnetic and acoustic excitation of a spin-system in the absence of a constant magnetic field is given and an expression is obtained for the expectation value of the operator Q which was introduced by the authors in a previous paper (ZhETF, 1961). An estimate is made of cross effects which appear as a result of the action of two-pulse magneto-acoustic generators on the spin system.

ASSOCIATION: Kazanskiy gosudarstvennyy universitet imeni V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin)

SUBMITTED: July 6, 1961

2344400

S/056/62/042/005/031/050
B102/B104

AUTHOR: Kopvillem, U. Kh.

TITLE: Pulsed excitation of systems of weakly interacting particles

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 5, 1962, 1333-1343

TEXT: A system of particles is considered in which the particles interact weakly with each other but, for a very short period t, react strongly with an external pulse generator. The time t is stated to be much shorter than the characteristic time τ of interaction between the particles. During t a selective excitation of the system occurs. The operator of interaction between system and generator will be a single-particle one with respect to excitation of the physical system so that a general solution of the Schrödinger equation for the conservative unit "system + generator" can be obtained, independently of the nature of the system and the generator. This solution can be applied to calculate the equations of motion of macroscopic quantities characterizing the non-equilibrium state of the many-particle system with a discrete energy spectrum, subjected to the

Card 1/3

exciting pulses. The study of such a non-equilibrium state is of interest for obtaining "negative" temperatures, investigation of relaxation processes and pulse spectroscopy. These states, however, can be attained only if $\tau \ll t$ and $\theta t = \pi$. Simple algorithms for the operator transformations related to pulsed excitation are derived. The general properties of the pulse generators are established as well as those of physical systems leading to oscillating and to steady response signals of the excited system. As an example, the resulting general relations obtained are applied in studying the non-equilibrium states of electron and nuclear spin systems produced by crossed magneto-acoustic excitation. For this purpose a dielectrical paramagnetic crystal is considered. The prospects of developing pulse techniques for investigating systems of electrical and orbital magnetic moments are discussed. The most important English-language references read as follows: I. J. Lowe, R. E. Norberg. Phys. Rev. 107, 46, 1957; W. B. Mims et al. Phys. Rev. Lett. 7, 2, A3. U. Fano. Rev. Mod. Phys. 29, 74, 1957; W. Bernard, H. B. Callen, Rev. Mod. Phys., 31, 1017, 1959.

ACCESSION NR: AR4022448 S/0058/64/000/001/D034/D034

SOURCE: RZh. Fizika, Abs. 1D271

AUTHORS: Koloskova, N. G.; Kopvillem, U. Kh.

TITLE: Theory of nuclear acoustic resonance line shape in cubic crystals

CITED SOURCE: Sb. Fiz. probl. spektroskopii. T. 2. M., AN SSSR, 1963, 133-135

TOPIC TAGS: nuclear acoustic resonance, magnetoacoustic resonance, spin photon interaction, spin phonon interaction, line shape, line width, absorption line shape, isotropic exchange interaction, non-adiabatic moment

TRANSLATION: A quantum-statistical theory of magnetoacoustic resonance is developed. It is shown that a noncritical extension of the

Card 1/2

ACCESSION NR: AR4022448

deductions of the general theory of ordinary magnetic resonance to include the case of excitation of a spin system by resonant phonons leads to considerable errors. Whereas spin-photon interaction is described by a linear function of the spin variables, spin-phonon interaction is in many cases bilinear relative to the spin of the nucleus or of the ions. The commutation rules, which determine the specific form of the solution of the Schrodinger equation, therefore give rise to many distinguishing features of magnetoacoustic resonance. Explicit formulas are presented in the paper for the calculation of the shape of the absorption line. Unlike magnetic resonance, isotropic exchange interactions broaden the central part of the magnetoacoustic resonance line. The presence of dislocations in the sample also greatly affects the shape of the absorption line. The resonance absorption line width increases nonlinearly with increasing spin. The nonadiabatic moments of the absorption curve are calculated in the paper. U. Kopvillem.

DATE ACQ: 03Mar64 SUB CODE: PH ENCL: 00

Card: 2/2

24.4400

45355

S/181/63/005/002/045/051
B102/B186

AUTHORS: Kessel', A. R., and Kopvillem, U. Kh.

TITLE: Theory of two-quantum magneto-acoustic transitions

PERIODICAL: Fizika tverdogo tela, v. 5, no. 2, 1963, 667 - 674

TEXT: The probability and line shape of magneto-acoustic two-quantum transitions (cf. N. S. Shiren, Phys. Rev. Lett., 6, 168, 1961) are calculated on the basis of approximate linear theory of irreversible processes. Such a theory is applicable when the actions of the two external fields are weak enough to be replaceable by one effective field. The two-quantum transition probability is calculated for the discrete spectrum of a system of N identical noninteracting particles with spin S, whose Hamiltonian is $\mathcal{H}_0 = \sum_{j=1}^{N} \mathcal{H}_0^j$. The result is:

$$W_{i\to f} = \frac{1}{16\hbar^4} \sum_{\alpha,\sigma} \{ |(\mathcal{H}'_A)_{i\alpha}|^2 |(\mathcal{H}'_M)_{\sigma f}|^2 (\omega_M + \omega_{\sigma f})^{-2} + |(\mathcal{H}'_M)_{i\sigma}|^2 |(\mathcal{H}'_A)_{\alpha f}|^2 \times (\omega_A + \omega_{\sigma f})^{-2} + 2\mathrm{Re}\{(\mathcal{H}'_A)_{i\sigma} (\mathcal{H}'_M)_{\sigma\alpha} (\mathcal{H}'_A)_{\alpha f} (\mathcal{H}'_M)_{\alpha i}\} \times \quad (7)$$
$$\times \{(\omega_M + \omega_{\sigma f})(\omega_A + \omega_{\sigma f})\}^{-1} \} \{\delta(\nu_A + \nu_M - \nu_{21}) + \delta(\nu_M - \nu_A - \nu_{21}) +$$
$$+ \delta(\nu_A - \nu_M - \nu_{21}) + 2\delta(\nu_M - \nu_{12}) \delta_{\nu_A, 0} + 2\delta(\nu_A - \nu'_{12}) \delta_{\nu_M, 0} \},$$

Card 1/3

is obtained for the energy absorbed per unit time, being accurate up to the second moment $\sigma_{4\nu}$ in rigid-lattice approximation. The results obtained for the second moment represent a generalization of those of M. N. H. Pryce and K. W. H. Stevens (Proc. Phys. Soc. A63, 36, 1951). The results are applied to the example of the Ni^{2+} ion in MgO. The theory makes it possible to eliminate the effects of dislocations, the resonance terms of magnetic dipole interactions and of isotropic exchange from the line shape formulas. For the Ni^{2+} paramagnetic ions the adiabatic second moment is e.g. obtained as $\sigma_{20}^2 = \frac{4}{9}C\langle(\Delta\omega)^2\rangle$ without dislocation and magnetic dipole interaction resonance contributions. C is the Ni^{2+} concentration and $\langle(\Delta\omega)^2\rangle$ the Van-Vleck second moment. There is 1 table.

ASSOCIATION: Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR
(Physicotechnical Institute of the Kazan' Branch AS USSR)

SUBMITTED: July 23, 1962 (initially)
October 1, 1962 (after revision)

KOPVILLEM, U.Kh.; NAGIBAROV, V.R.

Light echo on paramagnetic crystals. Fiz. met. i metalloved. 15 no.2:313-315 F '63. (MIRA 16:4)

1. Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR.
(Metal crystals—Optical properties)
(Paramagnetism)

44948

24.6500

S/048/63/027/001/031/043
B125/B102

AUTHORS: Kopvillem, U. Kh., and Mineyeva, R. M.

TITLE: On methods pulsed magnetic and sonic spectroscopy

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 27, no. 1, 1963, 93 - 95

TEXT: The possibilities of the pulse method of magnetic and sound spectroscopy are brought out by the example of a spin system excited by a high-frequency sound pulse without constant magnetic field. These calculations are made to establish a connection between the mean value μ_α (α=x, y, z) of the magnetic moment of the specimen for the time interval $\Delta t \ll t$ (τ is the shortest characteristic magnetic relaxation time) and the parameters A_1, B_1, Δt of the Hamiltonian

$$\mathcal{H}_{SL} = \sum_j^N [A_1(S_z^j S_x^j + S_x^j S_z^j)\cos\omega_0 t + B_1(S_z^j S_y^j + S_y^j S_z^j)\sin\omega_0 t], \quad (2)$$

of the interaction between the sound field and the spin system. Experimental measurements of $\langle\mu_\alpha\rangle$ in the instant Δt-t permit the investigation of the spin-phonon interaction in crystals. The solution of the Schrödinger

Card 1/3

On methods pulsed magnetic and sonic ... S/048/63/027/001/031/043
B125/B102

ASSOCIATION: Fiziko-tekhnicheskiy institut Kazanskogo filiala Akademii nauk SSSR (Physicotechnical Institute of the Kazan' Branch of the Academy of Sciences USSR); Kazanskiy gos. universitet im. V. I. Ul'yanova-Lenina (Kazan' State University imeni V. I. Ul'yanov-Lenin)

Card 3/3

24.6810

44949

S/048/63/027/001/032/043
B125/B102

AUTHOR: Kopvillem, U. Kh.

TITLE: On the use of magnetic and acoustic spectroscopy for the structural analysis of high-melting crystals

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 27, no. 1, 1963, 95 - 97

TEXT: The possibility is discussed of analyzing the spatial configuration of the internal electric fields in crystals by stationary and pulsed, resonance and non-resonance, magnetic and sound methods of exciting electron and nuclear spin systems. The additional widening of the magnetic resonance lines due to distortion of the E field by the lattice defects in artificial crystals makes it possible to study the nature of these defects. The index i denotes ions, the index j nodes. $f(S_\alpha)$ is the function of the spin operators S_α (α = x, y, z) which is equal for all j. The parameter D is assumed to have a certain normalized distribution $\varphi(D)$. The second moment of the line $|a\rangle \leftrightarrow |b\rangle$ of paramagnetic electron resonance has the form

Card 1/3

$$\overline{\langle(\Delta\nu)^{2s}\rangle}_{ab} = \langle(\Delta\nu)^{2s}\rangle_{ab}^{ik} + \langle(\Delta\nu)^{2s}\rangle_{ab}^{f}, \quad (2)$$ with

$$\langle(\Delta\nu)^{2m}\rangle_{ab}^{f} = h^{-2m} C \langle D^{2m}\rangle \{\langle a|f|a\rangle - \langle b|f|b\rangle\}^{2m}, \quad C = M/N,$$

$$\langle D^{2m}\rangle = \frac{1}{\gamma-\delta}\int_{\delta}^{\gamma}\varphi(D)\,D^{2m}dD, \quad (3)$$

(4)

for non-degenerate energy levels of the magnetic ions. The second summand in (2) is much more complicated with degenerate levels E_α. With nuclear resonance in crystals with axisymmetric $\mathcal{H}_0^1$

$$D^1 f(S_a) = -\frac{eQ(1-\gamma_\infty)}{2S(2S-1)}\sum_{\alpha,\beta} E_{\alpha\beta}\left[C_{zz\alpha\beta} - \frac{1}{2}(C_{xx\alpha\beta} + C_{yy\alpha\beta})\right] \times \times \left[S_z^{\alpha}S_z^{\beta} - \frac{1}{3}S(S+1)\right], \quad (6).$$

e is the electron charge, Q is the quadrupole moment of the nucleus, γ_∞ is the antiscreening factor, $E_{\alpha\beta}$ is the deformation tensor. The tensor with the elements $C_{\alpha\beta\gamma\delta}$ characterizes the change of the quadrupole energy of the nuclei by the dislocations. $\mathcal{H}_0^1$ is the first summand in the spin Hamiltonian

Card 2/3

KOPVILLEM, U.Kh.; KHABIBULLIN, B.M.

A paramagnetic particle counter. Zhur. eksp. i teor. fiz. 44 no.2:749-752 F '63. (MIRA 16:7)

1. Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR.

KOPVILLEM, U.Kh.; SHUBINA, R.V.

Double excitation of free induction and spin echo in crystals in the absence of a static magnetic field. Izv. vys. ucheb. zav.; fiz. no.5:6-13 '63. (MIRA 16:12)

1. Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR i Kazanskiy gosudarstvennyy universitet imeni V.I.Ul'yanova (Lenina).

KOPVILLEM, U.Kh.

Magnetic resonance and the structure of liquids. Zhur.strukt.khim. 4 no.6:912-913 N-D '63. (MIRA 17:4)

1. Kazanskiy filial AN SSSR.

KOPVILLEM, U.Kh.; NAGIBAROV, V.R.

Theory of the shape of optical and microwave absorption lines.
Fiz. tver. tela 5 no.10:2940-2950 O '63. (MIRA 16:11)

1. Fiziko-tekhnicheskiy institut AN SSSR, Kazan'.

ACCESSION NR: AP4013536 S/0181/64/006/002/0638/0639

AUTHOR: Kopvillem, U. Kh.

TITLE: Virtual temperature

SOURCE: Fizika tverdogo tela, v. 6, no. 2, 1964, 638-639

TOPIC TAGS: quantum mechanics, maser, laser, virtual temperature, relaxation transition, photon, phonon, magnon, spin phonon interaction, spin photon interaction

ABSTRACT: The temperature value in a quantum-mechanical system of identical weakly interacting particles is one of the most important dynamic characteristics. When the transition $E_\alpha \leftrightarrow E_\beta$ (individual values of the Hamiltonian of the separate particles) is caused by the simultaneous effect of $u \geqslant 1$ excitation quanta, the temperature does not uniquely define the dynamics of the system. The concept of virtual temperature,

$$V_{\alpha\beta\gamma} = a_\gamma T_{\alpha\beta}, \quad \gamma = 1, \ldots, u,$$

is introduced, characterizing the system relative to the quantum $h\nu_\gamma$, which permits the description of a number of different properties of multiquanta processes.

Card 1/2

ACCESSION NR: AP4013536

The value of a_γ may be 1 or -1, and is defined so that $V_{\alpha\beta\gamma} < 0$ when, as a result of the transition $E_\alpha \leftrightarrow E_\beta$, the probability of generating quanta $h\nu_\gamma$ is greater than the probability of their destruction. When $u = 1$, $a_\gamma = 1$. This concept of virtual temperature permits the following general conclusions: 1) the maser effect at a pair of levels (E_α, E_β) is possible for quanta of the type γ, if $V_{\alpha\beta\gamma} < 0$; 2) when $V_{\alpha\beta\gamma} \to 0$, the noise limit also tends toward zero; 3) when $u = 1$, spin-photon and spin-phonon interactions permit photons and phonons to be generated in masers and lasers only from magnons; when $u > 1$, either may be generated from either; 4) under steady conditions for a single-quantum maser effect, the inequality $T_{\alpha\beta} < 0$ does not alter the probability ratio of the $E_\alpha \leftrightarrow E_\beta$ relaxation transition. Orig. art. has: 3 formulas.

ASSOCIATION: Fiziko-tekhnicheskiy institut AN SSSR, Kazan (Physicotechnical Institute, AN SSSR)

SUBMITTED: 16Sep63 DATE ACQ: 03Mar64 ENCL: 00

SUB CODE: GP, EC NO REF SOV: 002 OTHER: 002

Card 2/2

ACCESSION NR: AP4019864 S/0181/64/006/003/0940/0941

AUTHORS: Nagibarov, V. R.; Kopvillem, U. Kh.

TITLE: Dynamic de-excitation of phonons

SOURCE: Fizika tverdogo tela, v. 6, no. 3, 1964, 940-941

TOPIC TAGS: phonon, optical acoustical transition; crystal lattice cooling, light polarization luminescence

ABSTRACT: Two-quanta optical-acoustical transitions make possible selective cooling of the lattice relative to phonons of definite frequency. Such transitions may be used as well for cooling the lattice as a whole. The cooling process is: a system of weakly interacting particles with a discrete energy spectrum $E_1 \leqslant E_2 \leqslant E_3$ is irradiated by monochromatic light having a frequency $\nu_0 < h^{-1}(E_3-E_1)$, where h is Planck's constant. If the polarization of light is such that the optic transition $E_1 \leftrightarrow E_3$ is forbidden by selection rules and the transition $E_1 \leftrightarrow E_2$ is allowed for acoustical vibrations, there will then occur two-quanta optical-acoustical transitions $E_1 \rightarrow E_3$ with absorption of phonons $h\nu_\varphi = (E_3-E_1)-h\nu_0$.

Card 1/3

ACCESSION NR: AP4028468 S/0181/64/006/004/1251/1253

AUTHORS: Kopvillem, U. Kh.; Golenishchev-Kutuzov, V. A.; Nagibarov, V. R.

TITLE: Nuclear quadrupole resonance in ferroelectric domain walls

SOURCE: Fizika tverdogo tela, v. 6, no. 4, 1964, 1251-1253

TOPIC TAGS: nuclear quadrupole resonance, ferroelectric, ferroelectric domain, ultrasonic perturbation, electric field perturbation, nuclear quadrupole energy operator

ABSTRACT: Theoretical computations are made of the effect of excitation of nuclear quadrupole resonance (NQR) in the domain walls of ferro- and antiferroelectrics by application of ultrasonics or a variable electric field at the resonant frequency. The variation of the electric field gradient inside the domain wall at the quadrupole nucleus is due to the shift of the wall relative to the nucleus (electric field effect) or of the nucleus relative to the wall (ultrasonic effect). These shifts have various amplitudes and at NQR frequencies are out of phase, hence the effects of ultrasonics and the electric field can be considered separately. It is assumed that the relative shift of nuclei and walls takes place

Card 1/3

ACCESSION NR: AP4028468

in a direction x perpendicular to the domain wall. The nuclear quadrupole energy operator takes the form:

$$R\mathcal{H}^{(1)} = \frac{1}{4}\alpha\left(I_z I_\pm + I_\pm I_z\right)(1-\gamma)\langle v_{xz}\rangle,\quad \alpha = \frac{\xi e Q}{I(2I-1)},$$

where ξ is the number of charges on particle i, e is electron charge, Q is the quadrupole moment of nucleus i, γ is the anti-shielding factor, $\langle v_{zx}\rangle$ is the average amplitude of variation of the electric field gradient component v_{zx}, I is the nuclear spin, and z is the direction of spontaneous polarization. For 90° walls with perturbation by an electric field of amplitude E,

$$\langle v_{xz}\rangle = (4\sigma^2 v_{xz})^{-1} M_{xz}\mu (E - E_0)$$

where σ is the wall thickness, E_0 is the critical field and μ is the wall "mobility". For E = 0.6,

$$\gamma\langle v_{xz}\rangle \sim 10^{13}.$$

Card 2/3

ACCESSION NR: AP4028468

With a relative deformation u_{xx} due to ultrasonic perturbation,

$$m_0\langle v_{ox}\rangle = \frac{M_1}{\rho} u_{xx}$$

Then for $u_{xx} = 10^{-4}$

$$\eta\langle v_{ox}\rangle \sim 10^{10}$$

(all values in cgs esu). Orig. art. has: 3 equations.

ASSOCIATION: Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR (Institute of Physics and Technology, Kasan Branch AN SSSR)

SUBMITTED: 06Dec63 DATE ACQ: 27Apr64 ENCL: 00

SUB CODE: PH NO REF SOV: 004 OTHER: 007

Card 3/3

ACCESSION NR: AP4009125 S/0056/63/045/006/2006/2008

AUTHOR: Nagibarov, V. R.; Kopvillem, U. Kh.

TITLE: Optoacoustic maser effect

SOURCE: Zhurnal eksper. i teoret. fiziki, v. 45, no. 6, 1963, 2006-2008

TOPIC TAGS: maser, optoacoustic maser, multiquantum maser, hypersonic vibration, anharmonic vibration, small strain measurement, millimeter wave, submillimeter wave

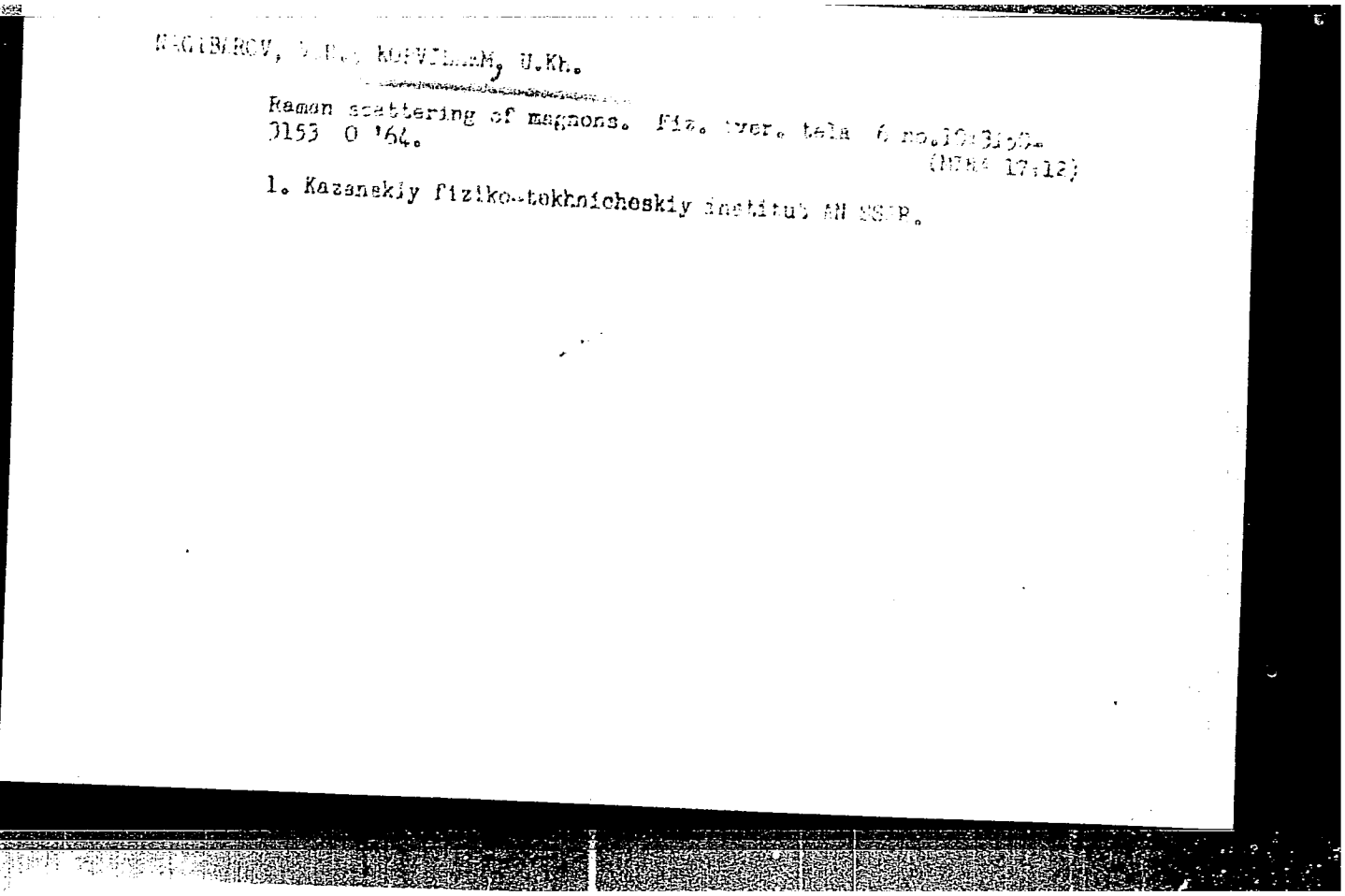
ABSTRACT: It is shown that in a maser system in which the working process involves the annihilation of an electromagnetic quantum at one frequency, the emission of a quantum at a different frequency and the creation of a quantum of potential energy, it is possible under suitable conditions to generate monochromatic quanta by using the energy of the optical pump. The advantages of this multiquantum maser over single-quantum ones are: (1) direct production of phonons from photons; (2) the effect occurs for normal level populations,

Card 1/3 2

NAGIBAROV, V.R.; KOPVILLEM, U.Kh.

Dynamic de-excitation of phonons. Fiz. tver. tela 6 no.3: 940-941 Mr '64. (MIRA 17:4)

1. Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR.



[illegible], U.Kh.

Raman scattering of magnons. Fiz. tver. tela 6 no.10:3153-[illegible] '64. (MIRA 17:12)

1. Kazanskiy fiziko-tekhnicheskiy institut AN SSSR.

KOPVILLEM, U.Kh.; NAGIBAROV, V.R.

Resonance broadening and energy transmission in optically excited systems with descrete spectra. Izv. vys. ucheb. zav.; radiofiz. 7 no.6:1204-1205 '64. (MIRA 18:3)

1. Kazanskiy fiziko-tekhnicheskiy institut AN SSSR.

ACCESSION NR: AP4031158 S/0056/64/046/004/1360/1362

AUTHORS: Kopvillem, U. Kh.; Nagibarov, V. R.

TITLE: Deformation cooling

SOURCE: Zh. eksper. i teor. fiz., v. 46, no. 4, 1964, 1360-1362

TOPIC TAGS: deformation cooling, adiabatic strain removal, cooling by strain removal, spin system temperature drop, degenerate level splitting, electron spin polarization, nuclear spin polarization, excited particle system cooling

ABSTRACT: It is shown that when a system of interacting particles with orbital and spin magnetism and with electric quadrupole moments (a deformed crystal) is subjected to splitting of its degenerate levels (by adiabatic removal of the strain), the system becomes cooled. A formula derived in the paper and published data are used to calculate the spin-system temperature drop, which is found to be

Card 1/3

ACCESSION NR: AP4031158

(in °K) on the order of 1 for the ground state of Fe^{2+} in MgO, 30 for the excited state of Eu^{2+} in CaF_2, 10 for Cr^{3+} exchange pairs in Al_2O_3, and 10^{-6} and 3×10^{-4} respectively for ^{133}Cs in metal and ^{115}In in InSb. It is shown that, unlike adiabatic demagnetization, the method of deformation cooling yields low temperatures in systems of excited particles. The possibility of using deformation cooling for the polarization of electronic and nuclear spins is also considered with Eu^{2+} in CaF_2 as an example. The feasibility of crystal cooling by deformation removal of degeneracy of nonmagnetic levels and by adiabatic removal of the electric field is also pointed out. Orig. art. has: 5 formulas.

ASSOCIATION: Fiziko-tekhnicheskiy institut Kazanskogo filiala AN SSSR (Physicotechnical Institute, Kazan' Branch, AN SSSR)

Card 2/3

L 12052-66 EWT(1)/EWP(m)/T IJP(c)
ACC NR: AP6002653 SOURCE CODE: UR/0386/65/002/012/0529/0533

AUTHOR: Kopvillem, U. Kh.; Nagibarov, V. R.

ORG: Kazan' Physicotechnical Institute, Academy of Sciences SSSR (Kazanskiy fiziko-tekhnicheskiy institute Akademii nauk SSSR

TITLE: Inertial echo and coherent gravitational waves

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki. Pis'ma v redaktsiyu. Prilozheniye, v. 2, no. 12, 1965, 529-533

TOPIC TAGS: gravitation wave, gravitation effect, graviton, laser application

ABSTRACT: In view of the universally recognized fact that one of the most promising experimental verifications of general relativity theory is the detection of gravitational waves, the authors consider new physical phenomena -- inertial (or gravitonic) induction and echo -- which in their opinion can be used for generation and reception of coherent gravitational waves (CGW) in a narrow band of optical frequencies under laboratory conditions. Numerical estimates show that the proposed experimental scheme on the detection of CGW can be realized with present-day technical means. The new phenomena are in fact the graviton analogs of the inertial induction and echo, which follow from the analogy between a weak gravitational field and the electric field and should apparently exist along with photon induc-

Card 1/3

Card 2/3

L 12052-66

ACC NR: AP6002653

6

lasers can emit a measurable power also in the form of CGW, amounting to 10^{-10} times the electromagnetic power delivered by the laser, and is therefore measurable. Authors are grateful to A. S. Borovik-Romanov and Ya. B. Zel'dovich for valuable remarks. Orig. art. has: 6 formulas.

SUB CODE: 20/ SUBM DATE: 18Oct65/ ORIG REF: 006/ OTH REF: 006

GC

Card 3/3

L 52001-65 EWT(m)/T IJP(c)

ACCESSION NR: AP5012571 UR/0181/65/007/005/1535/1544

AUTHOR: Kopvillem, U. Kh.; Khabibullin, B. M.

TITLE: On the theory of sensitivity of quantum counters

SOURCE: Fizika tverdogo tela, v. 7, no. 5, 1965, 1535-1544

TOPIC TAGS: quantum counter, elementary particle counter, elementary particle interaction, paramagnetic spin system, magnetic moment, [illegible] detector

ABSTRACT: A new principle is proposed for directly counting the number of elementary [illegible] and determining their kinetic energy and polarization. It is similar in the principle of the quantum counter proposed for [illegible] by N. Bloembergen (Phys. Rev. Lett. v. 2, 84, 1959) and by the author (with A. R. Kessel', FTT v. 4, 2083, 1962). It is based on the fact that interaction between elementary particles possessing a magnetic moment and the spin system of a paramagnetic crystal [illegible] possible to employ quantum electronic [illegible] masers, lasers, parametric [illegible] to investigate the interaction between elementary particles and determine their physical characteristics. The quantum mechanical theory of such [illegible], using the discrete energy levels of weakly interacting

Card 1/2

L 52001-65

ACCESSION NR: AP5012571

particles, is developed. The solutions are obtained for the [illegible] equations, with allowance for weak external background. To determine the sensitivity of the apparatus, a comparison is made of the change in level population produced by the noise and by the radiated signal. Spin-lattice, spin-spin, and cross relaxation processes are taken into account, and also the influence of forbidden transitions induced by the pump field. Methods are indicated for calculating the parameters which determine the optimal counter conditions. The results show that at low temperatures such systems could have high sensitivity for the detection of weak external signals. For example, at temperatures 0.1—0.01K such apparatus could be used to check the validity of the four-component neutrino theory, [illegible] the elastic scattering cross section of the neutrino ($\sim 10^{-38}$ cm^2) becomes measurable [illegible] at helium temperatures. Orig. art. has: 36 formulas. [02]

ASSOCIATION: Fiziko-tekhnicheskiy institut AN SSSR, Kazan' (Physicotechnical Institute, AN SSSR)

SUBMITTED: 26Mar63 ENCL: 00 SUB CODE: SS, NP

NO REF SOV: 011 OTHER: 008 ATD PRESS: 4009

Card 2/2

L 3346-66 EWT(1)/EPF(c) IJP(c) WW/GG

ACCESSION NR: AP5017294 UR/0181/65/007/007/2028/2035

AUTHOR: Kopvillem, U. Kh. 44,55

61
58
B

TITLE: Acoustic magnetic resonance and relaxation absorption by virtual phonons 44,55

SOURCE: Fizika tverdogo tela, v. 7, no. 7, 1965, 2028-2035

TOPIC TAGS: acoustic resonance, magnetic resonance, phonon, relaxation process, ion interaction, sound absorption

ABSTRACT: The author investigates theoretically the possibility of directly observing the interaction of ions with fields of virtual particles, by exciting resonance and relaxation transitions in quantum systems through modulation of the probability for the emission and absorption of virtual particles by the ions. The spin system of Fe^{2+} in MgO is considered as an example. Ultrasound is used to effect periodic changes in the crystal vibration spectrum, in the symmetry of the spin-phonon interaction tensor, and in the distances between the

Card 1/2

L 3346-66

ACCESSION NR: AP5017294

3

ions. This produces oscillations of the field of the virtual phonons at the Fe^{2+} ions and by the same token produce acoustic magnetic resonance and relaxation absorption. An operator formalism, based on irreducible tensor operators, is described for a description of some of the experimental results. Numerical estimates of the magnitude of the effect show that this type of acoustic magnetic resonance should be observable and may be responsible for the sharp increase in sound absorption with increasing concentration of Fe^{2+} ions in MgO, previously observed by D. J. Bolef et al. (Rev. Sci. Instr. v. 33, 631, 1962) and hitherto unexplained. Orig. art. has: 13 formulas.

ASSOCIATION: Kazanskiy fiziko-tekhnicheskiy institut (Kazan' Physicotechnical Institute)

SUBMITTED: 16Jan65 ENCL: 00 SUB CODE: GP, SS

NR REF SOV: 011 OTHER: 010

Card 2/2 DP

L 23853-66 EWT(1)/T IJP(c)

ACC NR: AP6013460 SOURCE CODE: UR/0139/66/000/002/0087/0091

AUTHOR: Kopvillem, U. Kh.; Khabibullin, B. M. 30 B

ORG: Kazan Physicotechnical Institute (Kazanskiy fiziko-tekhnicheskiy institut)

TITLE: Magnetic neutron counter 19

SOURCE: IVUZ. Fizika, no. 2, 1966, 87-91

TOPIC TAGS: particle counter, neutron counter, magnetic neutron counter

ABSTRACT: Based on numerous studies of Cr^{+3} in Al_2O_3 as the active medium of masers and lasers, a magnetic counter is proposed for recording energy spectra of neutrons and other neutral elementary particles, e.g., neutrinos and antineutrinos. Operation of the proposed counter is based on the conversion of the kinetic energy of a particle flux into quanta $\hbar\omega_{21} = E_2 - E_1$ of the potential energy of magnetic particles of the medium in the inner field of the crystal and on the subsequent count of spontaneously emitted photons of frequency ν_{21}. General theoretical calculations show that by sufficient lowering of the temperature, any degree of sensitivity of the counter can be achieved. Unlike some other similar elementary particle counters, this

Card 1/2 2

L 23863-66
ACC NR: AP6013460

device will react to any interaction capable of producing particle transition between levels E_1 and E_2. Generally, such an interaction depends on the pulse direction of the impinging particle and, consequently, can serve as an indicator of the direction of elementary particle fluxes in space. In contrast to counters which utilize nuclear reactions and require a very high initial kinetic energy, this device operates at an initial energy $\geq E_2 - E_1 = 100K$. External noise has little effect on the operation of the device at high frequencies ($\Delta E \geq 100K$). However, in the microwave and rf regions, the sensitivity threshold of the counter is determined chiefly by this noise. Both weak interactions of elementary particles and neutrinos with energies in the 0.025 ev—1 Mev range can be recorded. Orig. art. has: 8 formulas.

[JR]

SUB CODE: 20/ SUBM DATE: 17Mar64/ ORIG REF: 010/ OTH REF: 011
ATD PRESS: 4246

Card 2/2 dda

L 36435-66 EWT(1)

ACC NR: AP6015422 SOURCE CODE: UR/0051/65/020/005/0809/0813

AUTHOR: Kopvillem, U. Kh.; Nagibarov, V. R.

ORG: none

53
B

TITLE: Effect of collective interactions on the form of optical lines and energy transfer processes

SOURCE: Optika i spektroskopiya, v. 20, no. 5, 1966, 809-813

TOPIC TAGS: dipole interaction, spectral line, Brownian motion, phonon, excitation energy, potential energy, line broadening

ABSTRACT: The effect of electric and magnetic dipole-dipole interactions on the broadening of spectral lines and the processes of diffusion of excitations in the optical range are treated, taking into account the processes of resonance and relaxation mechanisms of excitation transfer. H_δ interactions ($\delta = 1, 2, 3$), which determine the broadening of spectral lines and the lifetime of optically active centers $j(=1,\ldots,)$ in the excited state ψ_α, are discussed: (1) electric dipole-dipole interactions via virtual states; (2) orbital magnetic dipole-dipole interactions via virtual states; (3) two-particle multipole-multipole interactions with the participation of phonons or Brownian motion quanta. The mechanisms of resonance transfer of potential energy quanta (magnons) between particles are examined. An expression is ob-

Card 1/2 UDC: 535.337

L 36435-66

ACC NR: AP6015422

tained for the coefficient of diffusion of excitation energy for Cr^{3+} in Al_2O_3 and MgO. Orig. art. has: 9 formulas.

SUB CODE: GE 20/ SUBM DATE: 05Sep64/ ORIG REF: 006/ OTH REF: 007

Card 2/2

ACC NR: AR6023269 SOURCE CODE: UR/0058/66/000/003/D050/D050

AUTHOR: Kopvillem, U. Kh.; Nagibarov, V. R.

82
B

TITLE: Quantum-statistical theory of Stark broadening of optical-resonance lines

SOURCE: Ref zh. Fizika, Abs. 3D425

REF. SOURCE: Tr. Komis. po spektroskopii. AN SSSR, t. 3, vyp. 1, 1964, 52-60

TOPIC TAGS: quantum statistics, group theory, Stark effect, quantum resonance phenomenon, resonance line, spin orbit interaction, particle interaction, electromagnetic interaction

ABSTRACT: On the basis of the method of the quantum aftereffect function, a theory is developed for the line contours of optical resonance in crystals at low temperatures. Allowance is made for the contribution due to the scatter of the intercrystalline electric fields, the spin-orbit interaction constant, and two-particle electric and magnetic multipole-multipole interactions. The operators of these interactions are expressed in the form of a contraction of irreducible symmetrical tensors, corresponding to definite point symmetry groups. In the case of single-particle inter-

Card 1/2

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actions and samples with small concentration of the resonant particles, an explicit closed expression is obtained for the sum of the perturbation series in terms of the internal interactions in the crystal. [Translation of abstract]

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apply the derived formulas to all outside disturbances with analogous symmetry properties. It is shown that the method of suppressing relaxation absorption by a

Card 1/2

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static field makes it possible to obtain information on exchange reactions in crystals. The effect of exchange suppression of relaxation absorption was studied in nickel fluorosilicate and confirms the theoretical deductions. Measurements are made of the spin-phonon interaction constant in nickel. [Translation of abstract]

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Card 2/2

ACC NR: AR7000842 SOURCE CODE: UR/0058/66/000/009/D049/D049

AUTHOR: Asadullin, Ya. Ya.; Kopvillem, U. Kh.

TITLE: Gradient acoustic paramagnetic resonance in liquids and gases

SOURCE: Ref. zh. Fizika, Abs. 9D389

REF SOURCE: Sb. Tezisy dokl. Yubileyn. nauchn. konferentsii, posvyashch. XX-letiyu in-ta. Kazansk. fiz-tekhn. in-t, 1966, Sekts. fiz. n. Kazan', 1966, 44-46

TOPIC TAGS: electron paramagnetic resonance, nuclear magnetic resonance, paramagnetic resonance, acoustic paramagnetic resonance, acoustic resonance, ultrasonic excitation, forced particle motion, magnetic field, acoustic signal conversion, spin induction, magnetic absorption, ultrasonic perturbation, nuclear spin

ABSTRACT: The experimental determination of acoustic electron paramangetic resonance (EPR) and nuclear magnetic resonance (NMP) in liquids and gases depends on the magnitude of the thermal and acoustic displacement of molecules at the resonance frequency. The determination is possible under ultrasonic excitation

Card 1/2

ACC NR: AR 7000842

of forced particle motion in the gradient of a magnetic field, bringing about a change in the degree of saturation in the acoustic conversion of EPR and NMP signals in the same sample. The coherence of acoustic displacements makes it possible to identify the effects of spin induction and echo; an analysis of mathematical expressions for the magnitude of magnetic absorption as a function of ultrasound, band width, and resonance frequency indicated the real possibility of observing these effects in liquids and gases. An evaluation is made of the probability of the relaxational transfer of the magnetic nucleus as a function of the interaction of μ_e with fluctuations in the electrical field for nuclei with an electric dipole moment μ_e. The use of ultrasonic perturbation in depolarizing nuclear spins H_e^3 is shown to improve the value of μ_e when compared with the known value of μ_e for a neutron. The gradient absorption of sound may also be determined from the shift in the threshold of laser generation. A. Vashman. [Translation of abstract] [SP]

SUB CODE: 20/

Card 2/2

GRIGOR'YEV, Vladimir Kirillovich; KOPYAKHIN, L.G., red.; LAZAREVA, L.V., tekhn.red.

[State management of collective farms] Gosudarstvennoe rukovodstvo kolkhozami. Moskva, Izd-vo Mosk.univ., 1961. 56 p. (MIRA 14:4)

(Collective farms)